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RADIATION TEMPERATURES OF THE EARTH'S MANTLE IN THE SUPERHIGH FREQUENCY AND INFRARED REGIONS BASED ON DATA FROM AN EXPERIMENT ON THE ARTIFICIAL EARTH SATELLITE KOSMOS-384

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1. The experiment on satellite Kosmos-384 was a continuation of the research program on superhigh frequency and infrared emission of the earth, begun on the satellite Kosmos-243 [1-3]. Kosmos-384 was placed into orbit on December 10, 1970. Height of the perigee was 212 kilometers; height of apogee - 314 kilometers; orbital inclination - 72.9°. /183*

The simultaneous recording of the strength of thermal emission in the superhigh frequency and infrared regions (10-12 micrometers) made it possible to establish the characteristics of the superhigh frequency emission spectrum and to estimate the variations in the degree of blackness of sections of the earth's surface.

The difference between seasonal conditions in the experiments on Kosmos-384 and Kosmos-243 made it possible to compare the radiation characteristics in different seasons.

2. In the Antarctic zone, the characteristics of seasonal conditions in the summertime appeared on the radiation character-

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*Numbers in the margin indicate pagination of original foreign text.

istics of superhigh frequency emission in the form of dips in the zones of rainfall and snowfall, "diffusion" of the boundaries of zones of floating ice, and in latitudinal changes in the radio brightness of mainland ice.

The boundary of floating ice, variations in the radio brightness of ice in the sea — related to a change in solidarity and the occurrence of snowfall on the ice surface — and the appearance of open water on the shores of Antarctica could be traced on the profile of the radio brightness temperature of the Antarctic zone, recorded in the 8 millimeter (Figure 1) channel. When the field of vision was shifted over the continent, regions could be observed with a decreased radio brightness temperature close to the coastlines, which points to increased emissivity of the surface, related to melting of the snow cover.

Figure 2 shows, for purposes of comparison, the measured values of radio brightness temperatures, radiation temperatures in the infrared channel, and mean monthly temperatures given in the Atlas of the Antarctica. As may be seen from Figure 2, there is agreement between the latitudinal changes of the ice cover temperature and latitudinal variations in the strength of thermal emission in the infrared and superhigh frequency regions. The observed changes in the radiation temperatures in the infrared and superhigh frequency region exceed the latitudinal variations obtained from mean monthly data by approximately 10-15°.

Figure 3 shows the latitudinal change in the degree of blackness of mainland ice in the 8-millimeter region obtained from concurrent processing of data on the infrared radiation temperatures and radio brightness temperatures in the same region. As may be seen in Figure 3, the degree of blackness of mainland /184

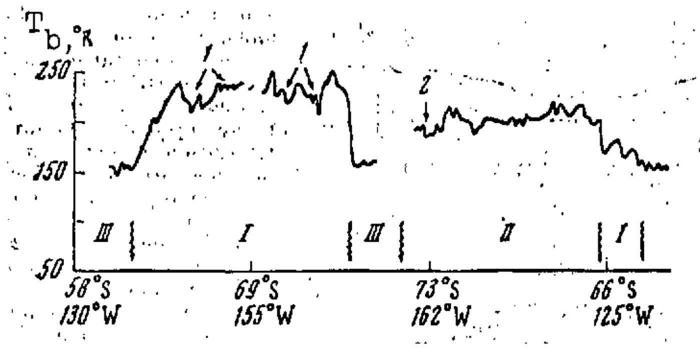

Figure 1. Profile of the radio brightness temperature of the Antarctic zone, December 10, 1970: I - Zone of icebergs; II - Zone of mainland ice; III - Space of open water; 1 - Regions of great rainfall or snowfall; 2 - Region of humid zone on the coast of Antarctica.

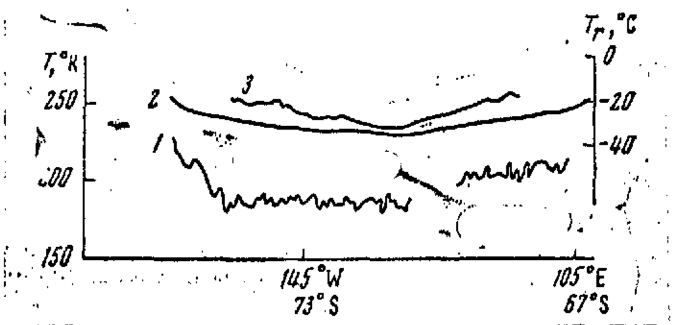

Figure 2. Comparison of radio brightness and infrared radiation temperatures with the mean monthly temperatures: 1 - Measured values of radio brightness temperatures; 2 - Mean monthly temperatures given in the Atlas of the Antarctica; 3 - Infrared radiation temperatures.

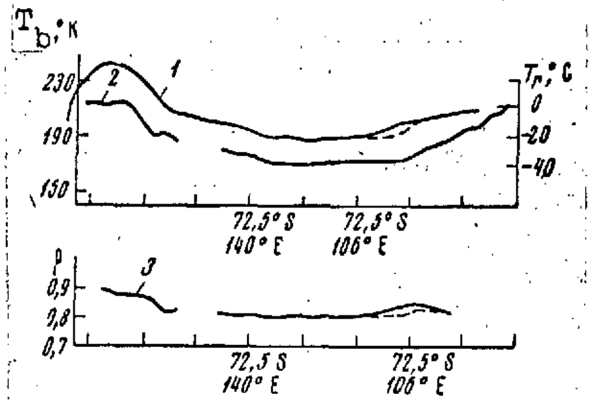

Figure 3. Measurement data on the infrared radiation and radio brightness temperatures and the degree of blackening of the Antarctic zone: 1 - Radio brightness temperatures in the 8-millimeter range; 2 - Infrared radiation temperatures; 3 - Estimates of the degree of blackness. /184

ice remains almost constant when the field of vision is shifted along the continent, and increases in the region of the coastline and of ice in the sea.

It follows from a comparison of the experimental results obtained on Kosmos-384 and Kosmos-234 that the estimates of the degree of blackness of mainland ice and continuous sections of icebergs in the spring and summer periods do not differ greatly.

3. Figure 4 gives data on the distribution of icebergs around Antarctica in December, 1970 obtained from radiometric measurements at a wavelength of 8 millimeters on the satellite Kosmos-384, and from processing television pictures from a satellite in the "Meteor" system.*

Three gradations of solidity of the floating icebergs were obtained from processing the radiometric data. It should be noted that a uniform interpretation of the radiometric data was complicated by the possible influence of melted water which appeared at this time of year on the surface of the ice due to intense thawing of the ice cover.

A comparison of the radiometric data with the data in television pictures shows that under cloudless conditions in the daytime, the television image gives a more detailed picture of the ice distribution, whereas at night-time (December, the Arctic) and during cloudy conditions the radiometric method has a clear advantage. Thus, Figure 4 shows the close coincidence of the edges of frozen ice based on radiometric and television data in cloudless and slightly cloudy regions (in the zone from

* The identification and analysis of television pictures was performed in the USSR Hydrometeorological Center under the leadership of K. P. Valil'yev.

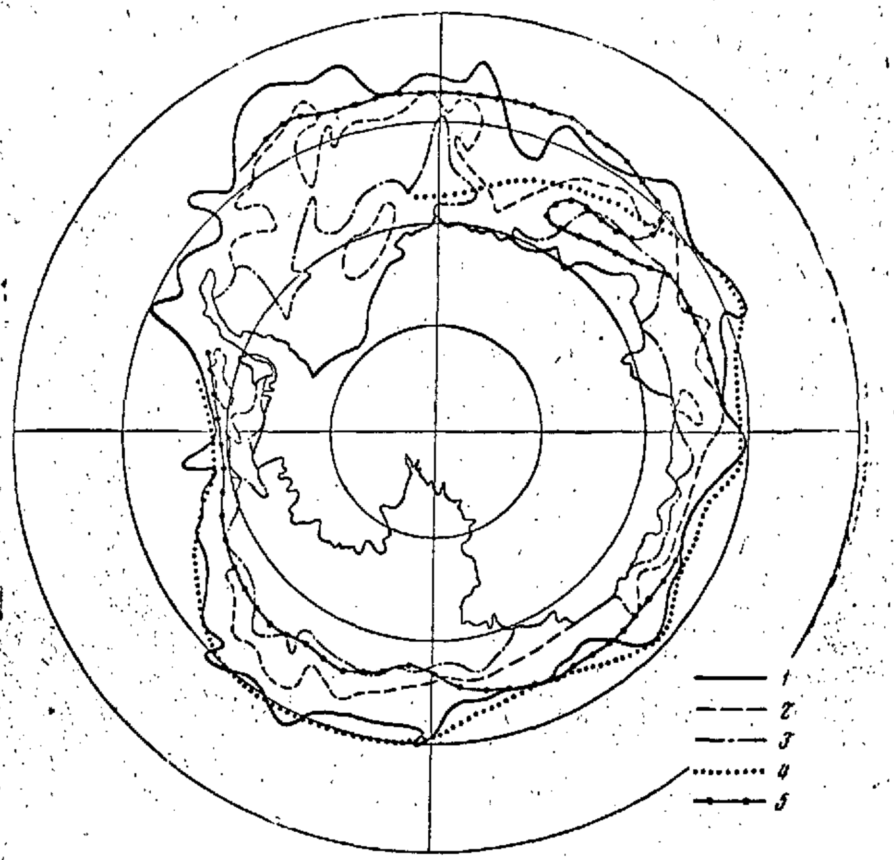

Figure 4. Map showing distribution of ice in Antarctica in December, 1970 based on data from radiometric measurements from the satellite Kosmos-384. 1 - Border of ice; 2 - Distribution boundary of three-point ice; 3 - Distribution boundary of seven-point ice; 4 - Border of ice based on data from the "Meteor" system; 5 - Mean climatic data on the distribution of ice in December. /185

80° W to 50° E) as well as their significant divergence during great cloudiness (in the zone from 50° E to 10° W).

During the flight over the surface of the continents, the spectral measurements of radio brightness showed latitudinal changes in the radio brightness temperature caused by variations in the thermodynamic temperatures, and the occurrence of spectral characteristics related to the form of the vertical temperature profile in the surface layer.

By way of an example illustrating the latitudinal behavior of temperature, Figure 5 shows the radio brightness profile obtained in the 8-centimeter wavelength region during a flight over Western Africa. A similar pattern is observed in the three-centimeter and 8-millimeter wavelength regions. As may be seen from the graph, there are three characteristic regions here: Section 1, which is characterized by a smooth decrease in the temperature from the shore (30 ± 3° C) to the Northern tropics; Section 2, with a practically constant temperature, (Northwestern part of the Sahara) and Section 3, corresponding to the mountain region along the Mediterranean coast. The observed radio brightness changes agree with the data on the temperature pattern of this region during winter in the Northern Hemisphere. Thus, based on synoptic data the temperature of the air on the Southern coast of Africa is (30±3°C), whereas on the Mediterranean coast, it is 16±2°C. The difference between the mean monthly values of the temperatures between these points is about 15°C.

A determination was made of the radio brightness spectral characteristics in the permafrost region of the North Pole in Siberia for which the radio brightness in the 8- and 3- centimeter wavelength regions is 263 ± 10°K; at a wavelength of 8-millimeters T_b = 240 ± 15°K. Such a significant spectral difference may be explained by the characteristics of the vertical temperature profile in the surface layer in frozen soil. At a wavelength of 8-millimeters the emission of the surface layer of the soil is determined, with a thickness of 10 ± 30 cm where temperature fluctuations are close to air temperature changes on the surface of the earth. But, based on synoptic data, the temperature of the air in this region is -37 ± 7°C.

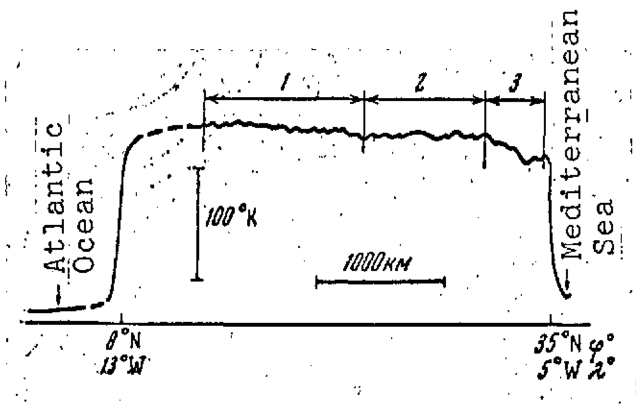

Figure 5. Profile of radio brightness of the Northwestern region of Africa. λ = 8.5 cm, December 10, 1970. /186

The radio brightness spectrum obtained was compared with the radio brightness spectrum of icebergs, adjacent to the coastline in the Red Sea, whose surface temperature was -8 to -14°C, based on synoptic data. Based on measurement data, the radio brightness in the entire superhigh frequency region was λ = 8.5 cm for the ice region. The radio brightness profile obtained during the flight over this region at a wavelength of 8-millimeters shows that there is a drop in the radio brightness during a flight over the coastline. In the 8- and 3- centimeter wavelength regions, the levels of emission for frozen soil and ice practically coincide.

A comparison of the data obtained on Kosmos-384 for this region of Siberia with the results of measurements on Kosmos-243 in the autumn (September, 1968) showed that the radio brightness temperatures of arid sections of the tundra zone in the 0.8—8 cm superhigh frequency region, do not differ greatly in a different season.

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16. Abstract

Represents a continuation of radiation experiments carried out by Kosmos 243. The following were determined for the Antarctic region: radio brightness temperature, infrared radiation temperatures, ice distribution. Observations of Africa are also described.

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